REMARKS

Prior to the present response, claims 1, 2, 4-7, 9-12, 14-17, 19, and 20-24 were pending in the present application. No amendment to the claims have been made. Thus, claims 1, 2, 4-7, 9-12, 14-17, 19, and 20-24 remain in the present application. Reconsideration and allowance of pending claims 1, 2, 4-7, 9-12, 14-17, 19, and 20-24 in view of the following remarks are requested.

A. Rejection of Claims 1, 2, 4-7, 9-12, 14-17, 19-24 under 35 USC §103(a)

The Examiner has rejected claims 1, 2, 4-7, 9-12, 14-17, 19-24 under 35 USC §103(a) as being unpatentable over U.S. patent number 6,858,506 to Kent Kuohua Chang (hereinafter "Chang") in view of U.S. patent application publication number 2004/0115929 A1 to Bi O. Lim (hereinafter "Lim") and in further view of U.S. patent application publication number 2005/0035460 A1 to Horng-Huei Tseng (hereinafter "Tseng"). For the reasons discussed below, Applicants respectfully submit that the present invention, as defined by independent claims 1, 6, 11, and 17, is patentably distinguishable over Chang, Lim, and Tseng, either singly or in any combination thereof.

The present invention, as defined by independent claim 1, includes forming an ultra-uniform silicide having approximately less than 3% variation in thickness on source/drain junctions and on a gate within a thermal budget having a temperature dependent upon a silicide metal. As disclosed in the present application, an ultra-uniform nickel silicide can form extremely robust nickel silicide, which has been found to be difficult to form. *See*, e.g., page 7, lines 22-26 of the present application. As disclosed in

the present application, "ultra-uniform silicide" is defined as a layer of silicide having no variations in thickness greater than about 3% of the overall thickness. *See*, e.g., page 7, lines 26-28 of the present application.

In contrast to the present invention as defined by independent claim 1, Chang does not disclose forming an ultra-uniform silicide having approximately less than 3% variation in thickness on source/drain junctions and on a gate within a thermal budget having a temperature dependent up a silicide metal. Chang specifically discloses forming silicide film 234 atop gate structure 208a and heavily doped source/drain regions 218 to lower the sheet resistance at the source/drain area and the gate electrode. *See*, e.g., Figure 2G and related text of Chang. Chang further discloses that nickel silicide can be used for silicide film 234 to reduce the consumption of silicon in gate structure 208a and strained silicon layer 204. *See*, e.g., column 5, lines 2-4 of Chang. However, Chang fails to disclose forming an ultra-uniform silicide having approximately less than 3% variation in thickness on source/drain junctions and on a gate, as specified in independent claim 1. Furthermore, Chang fails to disclose any relationship between the uniformity of silicide film 234 and the robustness of silicide film 234 or any reason for forming a silicide having a highly uniform thickness. In fact, Chang fails to even mention the uniformity of silicide film 234.

In contrast to the present invention as defined by independent claim 1, Lim does not disclose forming an ultra-uniform silicide having approximately less than 3% variation in thickness on source/drain junctions and on a gate within a thermal budget having a temperature dependent up a silicide metal. Lim specifically discloses forming a

tungsten nitride layer 37 in contact hole 12 in insulating layer 11 overlying semiconductor substrate 10 and depositing tungsten layer 39 on tungsten nitride layer 37, where tungsten nitride layer 37 can be deposited by an atomic layer deposition (ALD) process, and where tungsten nitride layer 37 and tungsten layer 39 are preferably in-situ deposited in the same reaction chamber. See, e.g., paragraphs [0020], [0021], and [0026] and Figures 3 through 8 of Lim.

However, Lim fails to disclose forming an ultra-uniform silicide having approximately less than 3% variation in thickness on source/drain junctions and on a gate, as specified in independent claim 1. Thus, Lim fails to cure the aforementioned deficiencies of Chang.

In contrast to the present invention as defined by independent claim 1, Tseng does not disclose forming an ultra-uniform silicide having approximately less than 3% variation in thickness on source/drain junctions and on a gate within a thermal budget having a temperature dependent upon a silicide metal. Tseng specifically discloses metal silicides 115 situated on gate electrode 111 and source/drain regions 113 in semiconductor substrate 100, where metal silicides 115 can be titanium silicide, cobalt silicide, or nickel silicide and can have a thickness between about 50 Angstroms and 350 Angstroms. *See*, e.g., paragraph [0037] and Figure 2 of Tseng.

In the outstanding Office Action, the Examiner states that Tseng teaches forming an ultra-uniform silicide having approximately less than 3% variation in thickness on source/drain junctions and on a gate. The Examiner further states one of ordinary skill in the art would be motivated to combine Chang, Lim, and Tseng, and that motivation for

doing so would have been to provide a semiconductor device with reduced contact resistance as taught by Tseng in paragraph [0009]. *See*, e.g., page 5, last paragraph and page 6, lines 1-3 of the outstanding Office Action. Applicants respectfully disagree for the following reasons.

A metal silicide 115 that can be about 50 Angstroms is not the same as an ultra-uniform silicide having approximately less than 3% variation in thickness on source/drain junctions and on a gate, as specified in independent claim 1. As disclosed in the present application, in an embodiment of the invention, silicides 604, 606, and 608 (e.g. ultra-uniform nickel silicides) can be formed by depositing nickel on exposed silicon areas by using a very low power deposition process, where "very low power" means a power level below 500 watts direct current. See, e.g., page 7, lines 29-32 and Figure 6 of the present application. As disclosed in the present application, the nickel can be deposition at an extra slow rate of metal deposition, which is defined to be below 7.0 Angstroms per second. *See*, e.g., page 8, lines 1-2 of the present application. Thus, in an embodiment of the present invention, an ultra-uniform, ultra-thin silicide can be advantageously provided by depositing a silicide metal (e.g. nickel) to a thickness of not more than 50 Angstroms at a deposition rate below 7.0 Angstroms per second and using an annealing process to convert the deposited silicide metal to the silicide. *See*, e.g., page 8, lines 3-7 of the present application.

Furthermore, Tseng, paragraph [0009] does not teach reducing contact resistance by forming an ultra-uniform silicide having approximately less than 3% variation in thickness on source/drain junctions and on a gate. Rather, Tseng is directed towards a

method for reducing contact resistance and improving electromigration resistance by using copper plugs, for example, conductive plug 160. *See*, e.g., paragraph [0045] and Figure 3 in Tseng.

In the outstanding Office Action, the Examiner, relying on In re Aller, states that having a 3% variation in thickness would be determined through routine experimentation and would not lend itself to patentability without unexpected results. See, e.g., page 6, lines 5-8 of the outstanding Office Action. However, as stated in In re Antonie, a particular parameter must first be recognized as a result-effective variable, i.e., a variable which achieves a recognized result, before the determination of the optimum or workable ranges of said variable might be characterized as routine experimentation. *See*, e.g., MPEP § 2144.05 section II subsection B. In the outstanding Office Action, the Examiner has allegedly found a similarity in the maximum thickness of a silicide layer in Tseng at 50 Angstroms, but not in the variation in thickness of a silicide layer. *See*, e.g., page 5, last paragraph, lines 4-7 of the outstanding Office Action. Tseng fails to disclose any relationship between the uniformity of metal silicides 115 and the robustness of metal silicides 115 or any reason to form a silicide having a highly uniform thickness. In fact, like Chang and Lim, Tseng does not even mention the uniformity of metal silicides 115.

There is no evidence of routine experimentation or optimization or that expected results were obtained. Conversely, as disclosed in the present application, in working with nickel silicide, it has been found to be difficult to form robust nickel. It has been thought that thick silicides around 100 Angstroms thick with rough surfaces would best protect the silicon substrate and provide good adhesion. *See*, e.g., page 7, lines 22-25 of

the present application. Thus, the overall thickness and roughness of a silicide was thought to be a critical factor as opposed to variation in thickness. However, in an embodiment of the present invention, an ultra-thin silicide, 50 Angstroms thick or less, and having less than 3% variation in thickness can be formed that provides adequate protection and good adhesion. *See*, e.g., page 8, lines 3-5 of the present application.

Thus, Lim fails to cure the aforementioned deficiencies of Chang. For the foregoing reasons, Applicants respectfully submit that the combination of Chang, Lim, and Tseng suggested by the Examiner does not and cannot result in the present invention as defined by independent claim 1.

For all the foregoing reasons, Applicants respectfully submit that, at the time the invention defined by independent claim 1 was made, the invention would not have been obvious to a person of ordinary skill in the art by Chang, Lim, and Tseng. Thus, independent claim 1 is patentably distinguishable over Chang, Lim, and Tseng and, as such, claims 2, 4, 5, 21, 22, and 23 depending from independent claim 1 are, *a fortiori*, also patentably distinguishable over Chang, Lim, and Tseng for at least the reasons presented above and also for additional limitations contained in each dependent claim.

Independent claims 6, 11, and 17 include similar limitations as independent claim 1. Thus, for similar reasons as discussed above, independent claims 6, 11, and 17 are also patentably distinguishable over Chang, Lim, and Tseng, either singly or in any combination. As such, claims 7, 9, 10, and 24 depending from independent claim 6, claims 12, 14, 15, 16 depending from independent claim 11, and claims 19 and 20 depending from independent claim 17 are, *a fortiori*, also patentable over Chang, Lim,

and Tseng for at least the reasons presented above and also for additional limitations contained in each dependent claim.

B. Conclusion

For all the foregoing reasons pending claims 1, 2, 4-7, 9-12, 14-17, 19, and 20-24 are patentably distinguishable over the cited art, and an allowance of pending claims 1, 2, 4-7, 9-12, 14-17, 19, and 20-24 is respectfully requested.

The Commissioner is hereby authorized to charge payment of any additional fees associated with this communication, or credit any overpayment to Deposit Account No. 50-0731.

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